Journal of Agricultural Science; Vol. 11, No. 8; 2019
ISSN 1916-9752 E-ISSN 1916-9760
Published by Canadian Center of Science and Education

Integrating Soybean Residues With Nitrogen Fertilizer for Improved Maize Production in Eastern Uganda

B. Sadina[1], A. Amoding[2], R. Amayo[1] & M. Biruma[1]

[1] National Semi-Arid Resources Research Institute, Serere, Uganda

[2] College of Agricultural and Environmental Sciences, Makerere University, Kampala, Uganda

Correspondence: B. Sadina, National Semi-Arid Resources Research institute (NaSARRI), P.O. Box 56, Soroti, Serere, Uganda. E-mail: sadina.beatrice@gmail.com

Received: November 1, 2018 Accepted: April 3, 2019 Online Published: June 15, 2019

doi:10.5539/jas.v11n8p206 URL: https://doi.org/10.5539/jas.v11n8p206

Abstract

Soybean has become one of the dominant crops in Ugandan farming systems; however the contribution of its residues to improve soil and crop productivity is less known. To investigate the role of soybean residues to enhance crop productivity, researcher-managed experiments were conducted for two seasons (2011B and 2012A) in Namayingo and Tororo districts, representing the L. Victoria crescent, and South-eastern L. Kyoga basin agro-ecological zones, respectively. Factorial treatments of three levels of soybean residues (0, 2 and 4 t ha^{-1}) and four levels of N fertilizer (0, 30, 60 and 120 kg ha^{-1} N) in form of urea were applied in maize fields in a randomized complete block design so as to; determine the optimum nutrient combination for maize, and establish the added yield benefits, if any, of using soybean residues with N fertilizer in maize production. Site yields varied significantly ($p < 0.001$), with higher maize yields obtained in Namayingo compared to Tororo. Significantly ($p < 0.05$) higher maize grain yields were obtained with the highest nutrient input combinations of 2 t ha^{-1} residue and 60 kg ha^{-1} N (yield increment of 71.72% above the control) in Namayingo district and 4 t ha^{-1} residue combined with120 kg ha^{-1} N increased maize grain yield by 140.69% above the control in Tororo. The added maize grain yield benefits ranged from 2540 kg grain ha^{-1} to 3250 kg grain ha^{-1} in Namayingo and from 2000 kg grain ha^{-1} to 2310 kg grain ha^{-1} in Tororo. Combined use of soybean residue with N fertilizer has been found to have agronomic yield benefits to maize production.

Keywords: added yield benefits, nutrients, soybean residue and maize

1. Introduction

Maize is a major staple crop in Eastern Africa (Kamanga et al., 2010; Kaizzi et al., 2012; Van Vugt, 2017), commonly grown either solely or integrated with legumes in a rotation and as an intercrop (Wortmann & Ssali., 2001; Waha et al., 2013) to address the rapidly declining soil fertility that has threatened food security (Garrity et al., 2010) in the region. Several low input soil fertility management technologies such as use of improved fallow plant species like *Mucuna pruriens*, and *Canvalia eniformis*, cowpea rotation with sorghum, use of organic and inorganic (N and P) fertilizers and practicing reduced tillage are reported to increase crop yields (Kaizzi et al., 2007). More recently, biomass transfer systems of *Tithonia diversifolia* have also been reported to increase yields of staple crops like maize (Jama et al., 2000; Muna et al., 2013). However, the residues of Soybean as one of the upcoming dominant crops in a maize-legume cropping system has been under exploited as a soil input. The sobeans generates about 1.32 t ha^{-1} residues (FAOSTAT, 2010) which have been mostly used as bedding for livestock or burnt off in the field (Lal, 2005). Yet studies from within the East African region, particularly in Western Kenya, have indicated positive yield responses of maize when soybean residues are added to the fields together with inorganic fertilizers (Okalebo et al., 1999) in order to replenish soil fertility. Since fertilizer use is less affordable among most, especially small scale, maize farmers, the exploitation of the potential of such locally available organic crop residues that could enhance yields of maize in eastern Uganda needed to be explored. These residues may be used alone or as a supplement to inorganic fertilizers such as N fertilizer. Limited information exists on the use of the soybean residues as a source of soil amendment and neither the required amounts of N fertilizer that needs to be integrated with soybean residue nor the added yield benefits from combined application of soybean residue with N fertilizer are known for the maize-legume systems of Uganda. Therefore, this study was

experimentation was similar to the usual amounts received in the area thus ruling out aspects of nutrient losses through leaching and runoff hence the observed positive added maize grain yields at both sites.

5. Conclusions

Combining soybean residues with N fertilizer significantly improved maize yields at both study sites but the input rates varied with the sites. Generally, better maize grain yields were far better at higher nutrient combinations rates at both sites. In addition, positive maize grain yield benefits are possible with combined application of the nutrient inputs at higher than lower rates particularly if the fields are degraded. Nutrient decomposition studies are recommended for a clear understanding of nutrient release patterns in legume crop residues for maize production, including cost benefit studies on combined use of N fertilizer and soybean residue in a maize/soybean cropping system.

Acknowledgements

We are grateful to the Alliance for A Green Revolution in Africa support through the soil health project of Makerere University, Africa 2000 Network, the host farmers, field assistants who greatly contributed to the success of the research findings.

References

Afridi, M. Z., Khan, A., & Akbar, H. (2012). Integrated management of crop residue and N fertilizer for wheat production. *Pak. J. Bot., 44*(6), 2015-2019.

Al-Kaisi, M. (2014). *Myths and facts about residue breakdown*. Iowa State University, Integrated Crop Management News.

Bationo, A., Kihara, J., Vanlauwe, B., Waswa, B., & Kimetu, J. (2007). Soil organic carbon dynamics, functions and management in West African agro-ecosystems. *Agricultural Systems, 94*(1), 13-25. https://doi.org/10.1016/j.agsy.2005.08.011

Bouyoucos, G. J. (1936). Directions for making mechanical analysis of soils by the hydrometer method. *Soil Sci., 42*, 225-230. https://doi.org/10.1097/00010694-193609000-00007

Bray, R. H., & Kurtz, L. T. (1945). Determination of total, organic, and available forms of phosphorus in soils. *Soil Sci., 59*, 39-45. https://doi.org/10.1097/00010694-194501000-00006

Bremner, J. M. (1960). Determination of nitrogen in soil by the Kjeldahl method. *The Journal of Agricultural Science, 55*(1), 11-33. https://doi.org/10.1017/S0021859600021572

Chivenge, P., Vanlauwe, B., & Six, J. (2009). Does the combined application of organic and mineral nutrient sources influence maize productivity? A meta-analysis. *Plant and Soil, 342*(1-2), 1-30. https://doi.org/10.1007/s11104-010-0626-5

Ebanyat, P. (2009). *A road to food? Efficacy of nutrient management options targeted to heterogeneous soilscapes in the Teso farming system, Uganda* (Doctoral Thesis, Wageningen University, the Netherlands).

FAOSTAT. (2010). *FAO Statistics Division 2010/06 November 2010*.

Foster, H. L. (1971). Rapid routine soil and plant analysis without automatic equipment: Routine soil analysis. *East Afr. Agric. For. J., 37*, 160-170. https://doi.org/10.1080/00128325.1971.11662519

Foster, H. L. (1981). The basic factors which determine inherent soil fertility in Uganda. *J. Soil Sci., 32*, 149-160. https://doi.org/10.1111/j.1365-2389.1981.tb01693.x

Garrity, D. P., Akinnifesi, F. K., Ajayi, O. C., Weldesemayat, S. G., Mowo, J. G., Kalinganire, A., ... Bayala, J. (2010). Evergreen Agriculture: a robust approach to sustainable food security in Africa. *Food Security, 2*(3), 197-214. https://doi.org/10.1007/s12571-010-0070-7

Gentile, R., Vanlauwe, B., Chivenge, P., & Six, J. (2008). Interactive effects from combining fertilizer and organic residue inputs on nitrogen transformations. *Soil Biology and Biochemistry, 40*(9), 2375-2384.

Gomez, K. A., & Gomez, A. A. (1984). *Statistical procedures for agricultural research* (2nd ed.). J. Wiley and Sons, NewYork.

Hanway, J. J., & Heidel, H. (1952). Soil analysis methods as used in Iowa state college soil testing laboratory. *Iowa Agri, 57*, 1-31.

Jama, B., Palm, C. A., Buresh, R. J., Niang, A., Gachengo, C., Nziguheba, G., & Amadalo, B. (2000). Tithonia diversifolia as a green manure for soil fertility improvement in western Kenya: A review. *Agroforestry Systems, 49*(2), 201-221. https://doi.org/10.1023/A:1006339025728

Jan, T., Jan, M. T., Arif, M., Akbar, H., & Ali, S. (2007). Response of wheat to source, type and time of nitrogen application. *Sarhad Journal Agriculture, 23*, 871-879.

Kaizzi, K. C., Byalebeka, J., Semalulu, O., Alou, I., Zimwanguyizza, W., Nansamba, A., … Wortmann, C. S. (2012). Maize response to fertilizer and nitrogen use efficiency in Uganda. *Agronomy Journal, 104*(1), 73-82. https://doi.org/10.2134/agronj2011.0182

Kaizzi, K. C., Byalebeka, J., Wortmann, C. S., & Mamo, M. (2007). Low input approaches for soil fertility management in semiarid eastern Uganda. *Agronomy Journal, 99*(3), 847-853. https://doi.org/10.2134/agronj2006.0238

Kamanga, B. C. G., Waddington, S. R., Robertson, M. J., & Giller, K. E. (2010). Risk analysis of maize-legume crop combinations with smallholder farmers varying in resource endowment in central Malawi. *Experimental Agriculture, 46*(1), 1-21. https://doi.org/10.1017/S0014479709990469

Lal, R. (2005). World crop residues production and implications of its use as a biofuel. *Environment International, 31*(4), 575-584. https://doi.org/10.1016/j.envint.2004.09.005

Macphee, W. S. G., & Ball, D. F. (1967). Routine determination of calcium and magnesium in soil extracts by atomic absorption spectrophotometry. *Journal of the Science of Food and Agriculture, 18*(8), 376-380. https://doi.org/10.1002/jsfa.2740180812

Mtambanengwe, F., & Mapfumo, P. (2006). Effects of organic resource quality on soil profile N dynamics and maize yields on sandy soils in Zimbabwe. *Plant and Soil, 281*(1-2), 173-191. https://doi.org/10.1007/s11104-005-4182-3

Mucheru, M., Mugendi, D., Micheni, A., Mugwe, J., Kung'u, J., Otor, S. & Gitari, J. (2002). Improved food production by use of soil fertility amendment strategies in the central highlands of Kenya. *Proceedings of the 8th meeting of the African Network for Soil Biology and Fertility research, Nairobi, Kenya* (pp. 92-108).

Muna, M. M., Mugendi, D. N., Pypers, P., Mugwe, J., Kung'u, J., Vanlauwe, B., & Merckx, R. (2013). *Enhancing maize productivity and profitability using organic inputs and mineral fertilizer in Central Kenya small-hold farms*.

Muyayabantu, G. M., Kadiata, B. D., & Nkongolo, K. K. (2012). Response of maize to different organic and inorganic fertilization regimes in monocrop and intercrop systems in a sub-Saharan Africa region. *Journal of Soil Science and Environmental Management, 3*(2), 42-48.

Okalebo J. K., G. K. W., & Woomer P. L. (2002). *Laboratory Methods of Soil and Plant Analysis: A Working Manual* (2 nd ed.). SACRED-Africa, Nairobi, Kenya.

Okalebo, J., Palm, C., Gichuru, M., Owuor, J., Othieno, C., Munyampundu, A., … Woomer, P. (1999). Use of wheat straw, soybean trash and nitrogen fertiliser for maize production in the Kenyan highlands. *African Crop Science Journal, 7*, 423-431. https://doi.org/10.4314/acsj.v7i4.27736

Palm, C. A., Gachengo, C. N., Delve, R. J., Cadisch, G., & Giller, K. E. (2001). Organic inputs for soil fertility management in tropical agroecosystems: Application of an organic resource database. *Agriculture, Ecosystems & Environment, 83*(1-2), 27-42. https://doi.org/10.1016/S0167-8809(00)00267-X

Schoessow, K. A., Kilian, K. C., & Bundy, L. G. (2010). Soybean Residue Management and Tillage Effects on Corn Yields and Response to Applied Nitrogen. *Agronomy Journal, 102*(4), 1186-1193. https://doi.org/10.2134/agronj2010.0033

Schröder, J. (2005). Revisiting the agronomic benefits of manure: A correct assessment and exploitation of its fertilizer value spares the environment. *Bioresource Technology, 96*(2), 253-261. https://doi.org/10.1016/j.biortech.2004.05.015

Ssali, H. (2002). Soil organic matter and its relationship to soil fertility changes in Uganda. In E. M. Nkonya et al. (Eds.), *Policies for improved land management in Uganda, Natl* (2nd, pp. 99-102). Worksh.

Thind, H. S., Sharma, S., Singh, Y., & Sidhu, H. S. (2019). Rice-wheat productivity and profitability with residue, tillage and green manure management. *Nutrient Cycling in Agroecosystems, 113*(2), 113-125. https://doi.org/10.1007/s10705-018-09967-8

Van Vugt, D., Franke, A. C., & Giller, K. E. (2017). Participatory research to close the soybean yield gap on smallholder farms in Malawi. *Experimental Agriculture, 53*(3), 396-415. https://doi.org/10.1017/S0014479716000430

Vanlauwe, B., Aihou, K., Aman, S., Iwuafor, E. N., Tossah, B., Diels, J., … Deckers, J. (2001). Maize yield as affected by organic inputs and urea in the West African moist savanna. *Agronomy Journal,* 93(6), 1191-1199. https://doi.org/10.2134/agronj2001.1191

Vanlauwe, B., Palm, C. A., Murwira, H. K., & Merckx, R. (2002). Organic resource management in sub-Saharan Africa: validation of a residue quality-driven decision support system. *Agronomie-Sciences des Productions Vegetales et de l'Environnement, 22*(7-8), 839-846. https://doi.org/10.1051/agro:2002062

Waha, K., Müller, C., Bondeau, A., Dietrich, J. P., Kurukulasuriya, P., Heinke, J., & Lotze-Campen, H. (2013). Adaptation to climate change through the choice of cropping system and sowing date in sub-Saharan Africa. *Global Environmental Change, 23*(1), 130-143. https://doi.org/10.1016/j.gloenvcha.2012.11.001

Wolkowski, R. P., Kelling, K. A., & Bundy, L. G. (1995). *Nitrogen management on sandy soils*. University of Wisconsin-Extension.

Wortmann, C. S., & Ssali, H. (2001). Integrated nutrient management for resource-poor farming systems: A case study of adaptive research and technology dissemination in Uganda. *American Journal of Alternative Agriculture, 16*(4), 161-167. https://doi.org/10.1017/S0889189300009140

Wortmann, C. S., & Eledu, C. A. (1999). *Uganda's agro ecological zones: A guide for planners and policy makers*. CIAT, Kampala, Uganda.

Appendix

Table A1. Average maize yield response to nutrient input application in Namayingo district (average of two seasons)

Analysis of Variance Variate: Dry Grain Yield_t/ha					
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Replicate stratum	3	0.41344	0.13781	2.35	
Replicate.*Units* stratum					
Sole_N	3	10.53563	3.51188	59.83	< .001
Sole_Residue	2	1.25829	0.62914	10.72	< .001
Season	1	23.02112	23.02112	392.2	< .001
Sole_N.Sole_Residue	**6**	**2.59754**	**0.43292**	**7.38**	**< .001**
Sole_N.season	3	0.24122	0.08041	1.37	0.259
Sole_Residue.season	2	1.51021	0.7551	12.86	< .001
Sole_N.Sole_Residue.season	6	2.29042	0.38174	6.5	< .001
Residual	69	4.05016	0.0587		
Total	95	45.91803			